THE EDUCATIONAL INFLUENCES OF PROJECT DESIGN EDUCATION ON STUDENTS' LEARNING ABILITIES
(The First Report)

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ABSTRACT

Project Design (PD) education system, a reformed educational system from the 1995-developed Engineering Design system of Kanazawa Institute of Technology (KIT), has been playing a crucial role in the curriculum of KIT. The PD education system (*PD Introduction, PD I, PD II, PD Hands-on, and PD III)* that applies Project-based Learning (PBL), aims to nurture graduates to become successfully independent thinking engineers or business people. Within the collaboration framework established in 2014 by KIT and Ho Chi Minh City University of Technology (HUTECH) in Vietnam, the KIT's PD I and PD II courses have been adopted by HUTECH for its newly founded institution, namely Vietnam - Japan Institute of Technology (VJIT) in order to equip VJIT's graduates with global industry-ready abilities and skillsets that are aligned with CDIO Syllabus. VJIT has been implementing these KIT's PD courses for three years. This paper reports the results of a preliminary research survey conducted at KIT and VJIT on the educational influences of PD I and PD II courses on students' learning abilities and skills. The results of the survey show positive influences of these PD courses on students' learning abilities and skills in both institutions. The research also yields some recommendations for improving the practices of PD courses in both KIT and VJIT in the future.

KEYWORDS

Project Design, CDIO Syllabus, learning abilities, open-ended problem, solving process

INTRODUCTION

The Project Design (PD) education system, formerly named Engineering Design, serves as the main pillar in the curriculum of Kanazawa Institute of Technology (KIT) with the incorporation of Project-based Learning (PBL) approach. According to Shekar (2014), PBL can benefit the learning of students, including: a) enabling collaborative learning and deep learning by developing close teamwork and realization of personal development, b) helping reduce rote learning and plagiarism with frequent assessment, and (c) bringing about active learning. At KIT, PBL is one of the key factors in ensuring the quality of engineering education as required by engineering accreditation boards such as Accreditation Board for Engineering and

Technology (ABET) and Japan Accreditation Board for Engineering Education (JABEE) (Ito et al., 2015).

In response to the increasing demand of industry and stakeholders in developing the desired attributes of engineers, many universities have been trying to address the necessity for reform in undergraduate engineering education. For this reason, the CDIO Initiative was developed to “educate students who are able to Conceive-Design-Implement-Operate complex, value-added engineering products, processes and systems in a modern, team-based environment” (Crawley et al., 2007, p. 1). Engineering education reform is “high on the agenda” worldwide and engineering skills have direct contribution to “the global economy, environment, security and health” (Campbell et al., 2009). In rethinking a new version for higher engineering education, Kamp (2016) notes that future engineers are not only “comprehensive problem solvers, but also problem definers, leading multidisciplinary teams in setting agendas, and fostering innovation” (p. 18). He further suggests three capabilities or roles that future engineers would need: a) “strong integrator capabilities to use and advance disciplinary expertise on its fringes, or fuse technological breakthroughs in one discipline with other disciplines”; b) capabilities of integrators to “synthesize, operate and manage across technical or organizational boundaries in a complex environment”; and c) “role of change agent, which means they must be prepared to provide the creativity, innovation, and leadership that is needed to guide research and industry to future success” (p. 21).

Beginning in 1995, KIT implemented several important educational reforms in engineering education. In 2006, KIT started to focus on development of students’ comprehensive integrated abilities, including academic disciplinary knowledge and personal and interpersonal skills (Sato, 2012). In 2011, as a further step of its continuous education reform, KIT joined the CDIO Initiative with the purpose of further improving its engineering education quality through international cooperation, aligning with CDIO Standards (Sato, 2012) while at present, CDIO is being promoted for both KIT’s curricular and extra-curricular activities. In 2012, Engineering Design of KIT was updated to the Project Design (PD) education system aligned with the CDIO Syllabus and Standards (Sato, 2012) to use for both engineering and non-engineering students. Now, the PD education system has been playing a crucial role in KIT’s curriculum and has been taught to students across 14 departments of KIT.

In 2015, KIT joined a collaboration program with HUTECH. Under this program, HUTECH has adopted KIT's PD I and PD II courses for its newly founded institution, the Vietnam-Japan Institute of Technology (VJIT) in order to equip VJIT’s graduates with global industry-ready abilities and skillsets that are aligned with CDIO Syllabus.

This paper aims to report the results of a preliminary survey of a joint international research project between KIT and VJIT, conducted at KIT and VJIT on the educational influences of PD I and PD II courses on students’ learning abilities and skills. The paper also puts forward some recommendations for improving the Project Design education in the future in both KIT and VJIT.

CHARACTERISTICS OF KIT’S PROJECT DESIGN EDUCATION

After university, engineers face multiple open-ended problems, which are usually addressed by a team. For this reason, the PD education system at KIT has been developed to satisfy those requirements and also provide students opportunities to: experience the process of engineering design, combine ideas and knowledge in team activities and individually, and create new ideas and values. They develop their approach to problem-finding and solving step-by step, from simple to complex toward the systematic solutions. Figure 1 shows the framework of the KIT’s comprehensive curriculum, in which the PD education system is the main pillar surrounded with knowledge-oriented education and hands-on education, with five following courses.

a) Project Design Introduction: Students experience experimental methods.
b) Project Design I (PD I): Students focus on creating ideas.
c) Project Design II (PD II): Students develop ideas created into shape.
d) Project Design Hands-on: Students verify ideas through experiments.
e) Project Design III (PD III): Students conduct a year-long project (a graduation thesis).

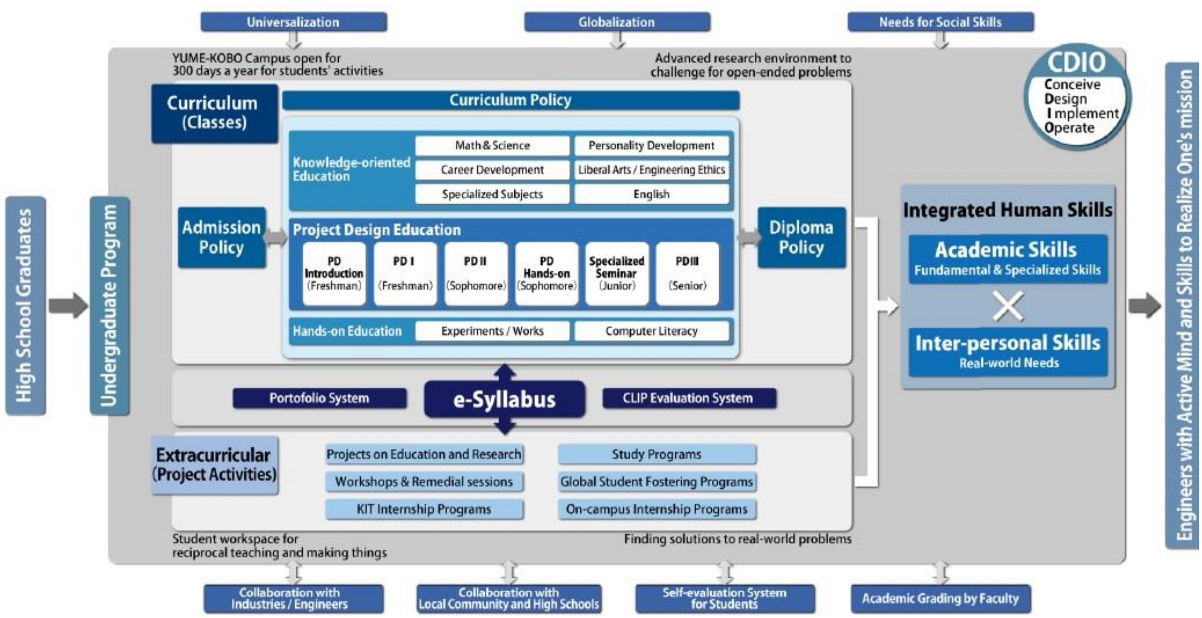

Figure 1. The current framework of KIT curriculum (Kanazawa Institute of Technology, 2017)

As the backbone of the KIT curriculum, PD education system has the following objectives (Kubo, Matsuishi, and Matsumoto, 2002; Saparon et al., 2017).

a) to train students to be independent thinking engineers through collaboration with others, learning the process and methods of problems identification and solving; solutions testing, verification and evaluation;
b) to allow students to think, act independently, and to implement active thinking; and
c) to allow students to present their creative results in a detailed and clear manner.

In short, KIT's PD education system provides students with problem solving skills, verification process skills, and innovation skills, which are needed to become successful engineers or businessmen in real life workplace. These are the key outcomes of the KIT's PD education (Ang et al., 2017; Saparon et al., 2017).

Project Design I & II Courses

In this paper, only the PD I and PD II courses are emphasized because they are directly related to our international research project. PD I, which is taken by freshmen, focuses on learning the process of acquiring problem solving skills by identifying a problem, collecting the information required, and reporting ideas. PD I has the following characteristics (Saparon et al., 2017).

(a) Integrate knowledge acquired from primary to secondary school, including university freshman course into solving a real-world problem. Scope and level of tasks are within the bounds of what students have previously learned.
(b) Discover a problem → Grasp current condition → Analyze the cause → Set the preconditions and desired conditions for the solution → Propose a solution for the problem.
(c) The main theme is presented as scope of the problem.
(d) Instructors are facilitators, supporting and encouraging students to be active participants.
(e) Problems are derived from students' own lives (or someone close to them).
(f) Promote awareness of the problems around them.
(g) Understand that there are many possible solutions to real-world problems and that it is necessary for those from different fields to work together.

PD II, which is offered for sophomores, also concentrates on the process of acquiring problem solving skills, but it addresses a different level of problems. This course requires students to tackle real-world problems (including those from local organizations or local governments) and to link with the PD Hands-on by making a plan to realize the concept selected.

Process of PD I & PD II Courses

In the PD course, students are taught many different approaches and students have to go through a process of solving that problem. Figure 2 describes the process of the PD I & PD II courses at KIT with five basic steps.

a) *Problem identification:* Students identify the problem around them.
b) *Problem clarification:* Students collect information and analyze the information related to the problem being addressed, and clarify the problem.
c) *Specifications establishment:* Students determine required specifications to be solved.
d) *Idea creation:* Students create as many ideas/ solutions as possible to solve the problem.
e) *Idea evaluation and selection:* Students evaluate and select the best idea/ solution among those developed.

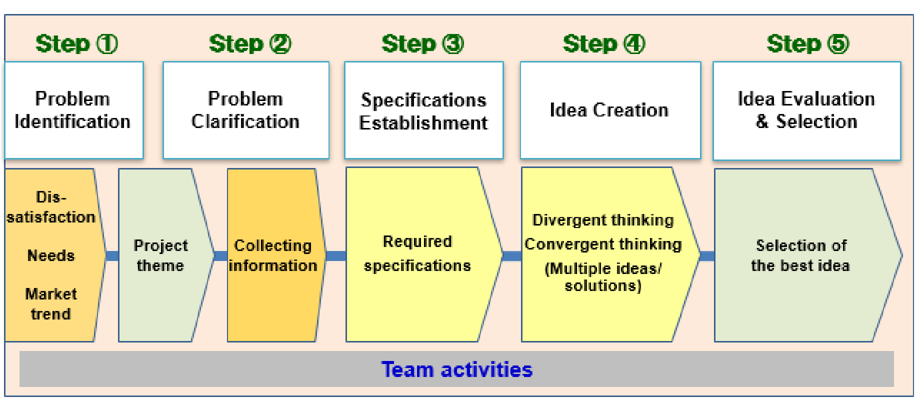

Figure 2. The process of PD I & PD II courses (Sentoku & Iwata, 2014)

During the course, students work on individual assignments and team assignments in equal amounts. Teamwork is one of the key characteristics of PD education. The students' performances are assessed based on their completion of both individual and team work (50% each), including worksheets, oral/ poster presentations, and final reports.

COLLABORATION PROGRAM BETWEEN KIT AND VJIT (HUTECH)

HUTECH has adopted the Project Design education system of KIT (currently PD I and PD II courses) for its newly founded institution, namely Vietnam-Japan Institute of Technology (VJIT) since 2015. Every year, VJIT sent their PD facilitators to attend PD professional training workshops at KIT to update their PD curriculum and facilitation skills. By adopting KIT's PD education, VJIT aims to equip VJIT's graduates with increasing globally desired skills and market needed abilities that are related to CDIO Syllabus and standards.

In implementation of these PD courses, there is a difference in the PD workflow between KIT and VJIT due to the different semester structure in the two institutions. For this reason, basic steps of the PD I and PD II courses, such as *problem identification, problem clarification, specification establishment, idea creation, idea evaluation and selection*, vary in weekly sessions in both KIT and VJIT (Figures 3.1 & 3.2).

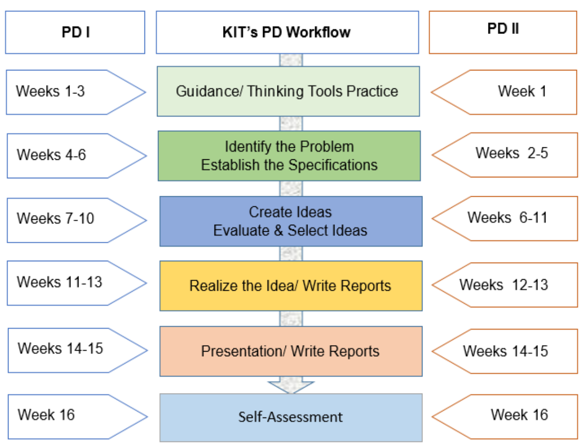

Figure 3.1 The PD I & PD II workflow in KIT

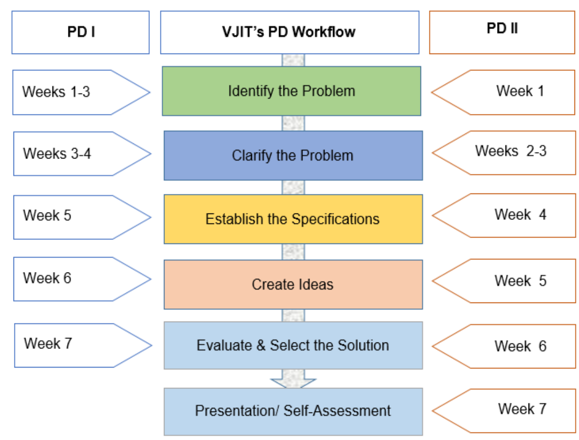

Figure 3.2 The PD I & PDII workflow in VJIT

A CASE REPORT OF THE PRELIMINARY SURVEY ON THE JOINT INTERNATIONAL RESEARCH PROJECT

This part of the paper reports the results of a preliminary research survey conducted in KIT (Japan) and VJIT (Vietnam) on the educational influences of PD I and PD II courses on students' learning abilities and skills, which are aligned with the CDIO Syllabus. The objectives of this international research project are to investigate the educational influences of these PD courses on the students' learning, especially on nurturing graduates to become successful engineers or business people in the future.

About the survey

The study used two types of survey questionnaire, one for PD instructors and the other for students. The Japanese versions were administered to the KIT's PD instructors and students, and the concurrent Vietnamese and English versions were used for VJIT's PD instructors and students. The content and number of questions are the same in two survey questionnaires.

Both types of survey questionnaires consist of two main parts. The first part asks about the general background of the respondents, such as gender, age, and specialization. The second part asks the respondents to rate: a) the influences of PD I and PD II on nurturing students' abilities (Items 1-16), b) the influences of PD I and PD II on students' learning of the specialized courses (Question 17), c) the satisfaction (Question 18) in learning PD courses (for students) and in teaching PD courses (for instructors) by developing the five-point Likert scale (1: *least influential and* 5: *most influential*). The following are 16 types of abilities investigated in the surveys of instructors and students, some of which are adapted from 'Desired Attributes of An Engineer' of the Boeing Company (Crawley et al., 2009).

An ability: *1) to tackle an open-ended problem in the real world*
2) to identify customers' and societal needs
3) to discover and solve a problem
4) to make a presentation before an audience
5) to act and collaborate in a team (teamwork)
6) to lead a team (leadership)
7) to develop discussions in a team
8) to conduct good communication skills (written, oral, graphic, and listening)
9) to think critically, creatively, independently, and cooperatively
10) to understand the design process
11) to design things or systems useful for human society
12) to implement things or systems designed
13) to operate things or systems implemented
14) to practice high ethical standards
15) to adapt to changes (flexibility)
16) to learn for life (lifelong learning)

Survey Administration

In July 2017, two survey questionnaires were administered to VJIT, one for PD instructors and one for students, using Google Forms online. The online surveys were open for two weeks for accepting responses. In the end, ten complete responses from VJIT's PD instructors and 206 complete responses from VJIT's PD students of various specialized fields were received. At KIT, the questionnaires were printed and distributed to 97 PD II mechanical engineering students and 18 PD instructors.

RESULTS ANALYSIS AND DISCUSSION

Mapping of the abilities surveyed to the CDIO Syllabus

Since this research investigates the influences of the PD I & PD II courses on students' learning abilities (Items 1-16 in the questionnaire), a mapping has been constructed to show the correlation of the surveyed abilities to the first level of detailed content of the CDIO Syllabus (*ver. 2.0*). The purpose of this mapping is to confirm the correlation between the abilities/ skills learned from PD I & PD II courses and the contents of the CDIO Syllabus. Details can be seen from Table 1 below. Due to the limited extent of the current research, content 1 (*Disciplinary Knowledge and Reasoning*) of the CDIO Syllabus has weak correlations with the abilities surveyed, while contents 2 and 4 have more correlations.

Table 1. Mapping of the surveyed abilities to the CDIO Syllabus

CDIO Syllabus (Ver. 2.0)	Abilities surveyed															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 Disciplinary Knowledge and Reasoning	△	△	△						△	△	△	△	△			
2 Personal and Professional Skills and Attributes	△	△	○	△	△	△	△	△	○	○	△	△	△	○	○	○
3 Interpersonal Skills: Teamwork and Communication	△	△	△	○	○	○	○	○								
4 Conceiving, Designing, Implementing & Operating Systems in the Enterprise, Societal & Environmental Context – the Innovation Process	○	○	○	△	△	△	△	△	△	○	○	○	○	△	△	△

△: Weak correlation ○: Strong correlation

The survey results from the instructors

The results for instructors' ratings are presented in Figure 4 below.

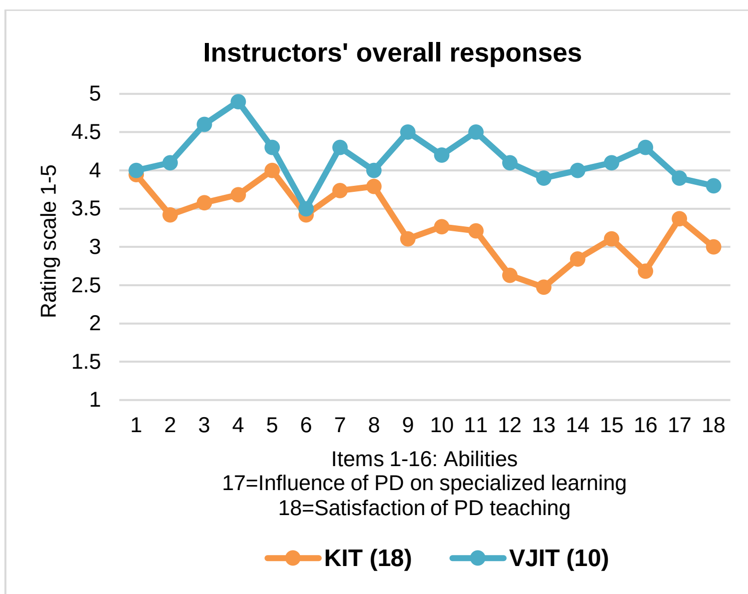

Figure 4. Instructors' rating

Figure 4 shows that the data distribution of the VJIT's instructors seems to be higher than that of the KIT's instructors on the rating scale (*1-5*) (VJIT's data *Mean*: *4.1*; KIT's data *Mean*: *3.2*). This may imply the influence of instructors' backgrounds and PD teaching experiences on the rating. The highest ratings of the items 1-16 by VJIT instructors are recorded on Items 4 (*4.9*), 3 (*4.6*), 9 and 11 (*4.5*), whereas KIT instructors rate Items 5 (*4.0*), 1 (*3.95*), and 8 (*3.78*) as the highest.

Of the Items 1-16 rated by VJIT instructors, some of the lowest ratings are found on Items 6 (*3.5*) and 13 (*3.9).* For KIT instructors, some of the lowest ratings fall on Items 13 (*2.47),* 12 (*2.63),* and 16 *(2.68)*. These low ratings indicate low influences of PD I and PD II courses on students' learning abilities, which can be predictable because these abilities can be obtained in advanced PD courses, such as PD Hands-on and PD III at KIT. We expect to investigate the influences of these abilities on students' learning of advanced PD courses in our future research.

The survey results from the students

There were 206 VJIT's PD II students and 97 KIT's PD II students participating in this preliminary research. Figure 5 shows the data of students' rating on 18 items, in which items 1-16 refer to learning abilities, item 17 asks about the influence of PD I and PD II on students' specialized learning, and item 18 asks students' satisfaction in learning PD I and PD II courses. For the purpose of better viewing, the original rating scale (1-5) has been zoomed in the scale of 3-4.

In Figure 5, the plotted data (Items 1-16) shows a relatively similar distribution of quantitative data collected from KIT's and VJIT's students (VJIT's data *Mean*: *3.99*; KIT's data *Mean*: *3.77*). This quantitatively indicates a consistency of students' rating of PD abilities (KIT: Highest *3.92*, lowest *3.61*; VJIT: Highest *3.97*, lowest *3.59*). Of the Items 1-16, some highest ratings are found for VJIT on Items 5 (*3.97*), 14 (*3.92*), and 7 (*3.89*); for KIT on Items 5 (3.92), 8 (*3.86*), 3 (*3.82*), and 7 (*3.82*). The similar ratings of both KIT and VJIT students indicate PD I and PD II have influences on students' learning abilities of *acting and collaborating in a team* (Item 5) and *developing discussion in a team* (Item 7).

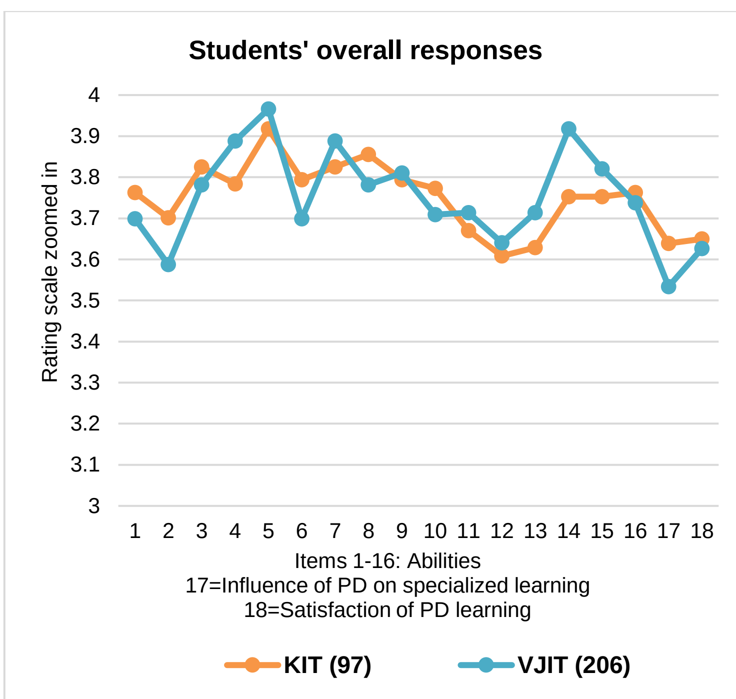

Figure 5. Students' rating

The lowest ratings are found for VJIT on Items 2 (*3.59*), 12 (*3.64*), and 1 *(3.7*); and for KIT on Items 12 (*3.60*), 13 (*3.62*), 11 (*3.67*), and 2 *(3.7*). The low ratings of Items 12 and 13 from both institutions' students are predictable as explained earlier in the instructors' data analysis. This result is consistent with the instructors' rating for these items. It is also necessary to note that compared to other items, Item 2 is rated as the lowest by VJIT students and also low by KIT students. This could be due to the inadequate provision of either course instruction or course activities that did not direct students' investigation into customers' and societal needs. This implies a need for improving this point in future PD courses. In terms of rating consistency between the instructors and students, the plotted data from Figures 4 and 5 shows a more consistent rating between instructors and students in KIT than VJIT.

Question 17 in Figure 5 shows ratings of the influence of PD I and PD II on students' learning of their specialized courses with a score of *3.64* for KIT and *3.53* for VJIT, which is quite consistent. These results confirm the consistency on the rating of this question from both institutions' instructors and students. Data of Question 18 shows both VJIT and KIT students' satisfaction in their learning of PD I and PD II courses (VJIT: *3.63*; KIT: *3.65*).

CONCLUSION

This preliminary survey as part of our three-year research project on Project Design education has attempted to investigate the influences of PD I and PD II courses on nurturing students' learning abilities. Sixteen abilities used in this research to survey the PD instructors and students from KIT and VJIT were correlated with the CDIO Syllabus contents. The findings revealed quite similar and consistent ratings from both instructors and students from KIT and VJIT. PD I and PD II courses had the most influence on students' learning abilities to *act and collaborate in a team (teamwork),* to *develop discussions in a team,* and to *conduct good communication skills (written, oral, graphic, and listening), and* the least influence on their abilities to *implement things or systems designed* and *operate things or systems implemented.* This result is predictable because the abilities with low influence from PD I and PD II courses are taught in advanced PD courses, such as PD Hands-on and PD III at KIT. Some important low ratings of other abilities are worth mentioning here, such as the abilities to *identify customers' and societal needs, to lead a team (leadership),* and *to learn for life (lifelong learning).* These low ratings have provided important insights for our future PD course design and classroom instruction in both institutions.

Since the current research is a preliminary one, its results, which are mainly quantitative, for external use may be limited. Our future research will continue to use the same questionnaire to students from KIT and VJIT to validate the results obtained from this research. Moreover, the findings reported here may not confirm all practical influences of PD education, but they have provided useful insights into PD education practices, PD curriculum reform, and PD instructors' training program in both KIT and VJIT.

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BIOGRAPHICAL INFORMATION

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